

Variation of the Blind Spot With Age

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VARIATION OF THE BLIND SPOT WITH AGE

The blind spot, or area coeca, has been involved in almost every controversy regarding the eye and its function since its discovery by Mariotte 290 years ago. It has played a role in the discussions of the seat of vision, the ability of the optic nerve to respond to light, space and binocular perception, the locus of contrast and other visual phenomena. Today the variations of the visual field have been and are still being extensively studied and perimetry has become one of the most important examinations of extramacular perception and a part of every thorough ophthalmological and neurological examination, being especially imperative in not readily accountable visual disturbances. However, from the standpoint of practical perimetric work, it is important to know not only the average size, shape, and position of the blind spot, but also the variations to be expected among normal eyes. Without this knowledge, diagnostic perimetry would be impossible in borderline cases. It is also important that these variations among normal eyes be sufficiently small or predictable so that pathological conditions produce relatively significant changes. Many investigators, in attempting to establish definite boundaries of the normal blind spot, have arrived at widely varying results due to variations in the methods, equipment, and conditions of the examination as well as the variations that already occur in the normal eye; best exemplified in the differences noted between the right and left eye in the same individual. As a result, no real comparison of the results is possible and it has even been suggested that each clinic should perhaps establish its own normal values.

The object of this investigation has been to evaluate the effect of one variable, the age of the patient, to determine its influence statistically and so decide, if variations do follow, whether they are significant enough so that allowance should be made for them in the interpretation of clinical results. There have been few reports of other investigators and their conclusions have been conflicting. Van der Hoeve found that in people of various ages the average size remained unchanged, but he does not detail the size of his series or the specific age of the subjects examined. Sharpley and Mann furnished indirect evidence that the change with age would be small. They state that, "there is no evidence to show that the light sensitivity of the retinal periphery is affected by age relatively more than the central areas." These observers were examining the visual fields of 80 subjects, ranging from 10 to 70 years in age, and although there was a considerable spread of values within each age group, there appeared to be an "apparent" tendency for the field to contract with age. However, this could not be statistically validated from the figures presented. Wentworth, in a study of the blind spots of 200 normal persons under standardized conditions, showed variations in area from 6.8 to 17.5 sq. cm., the average being 11.4 sq. cm., 33 cm. from the eye. He noted that the average size of the blind spots of 98 eyes of persons over 25 years of age was 11.6 sq. cm., or .8 sq. cm. greater than the average of 88 blind spots for persons 25 years of age, or under. He felt that the series was too small for generalization and that the difference is not significant for clinical diagnosis when compared to the mean deviation from eye to eye of 1.6 sq. cm. He also found the blind spot for 88 eyes of persons 25 years of age or under was 13.8, 16.6, and 21.4 sq. cm. for blue, red, and green stimuli respectively as compared to 15.2, 18.4, and 22.8 sq. cm. for 108 eyes of persons older than 25 years. Although Wentworth observed that the results, when plotted "approximate roughly the normal Gaussian frequency curve, the great range and the great amount of scatter make it difficult to determine the borderline between pathological and nonpathological groups and to limit the group of suspicious cases."

In order to appreciate the difficulty of attempting to isolate the effect of one factor on the size of the blind spot one must be cognizant of the divers factors that are known to influence its size in the normal eye and try, insofar as possible, to eliminate or minimize them. However, it is at once obvious in looking over the following classification, largely taken from

Dubois-Paulson, that only by examining a very large group of subjects could one hope to diminish the relative influence of the other factors sufficiently for the variations due to age to become statistically apparent and significant.

Factors causing enlargement of the blind spot are: (1) mouth breathing, (2) voluntary apnea, (3) preceding illumination, i.e. incomplete dark adaptation, (4) illumination of the other eye, (5) compression of the cervical veins, i.e. tight collar, (6) compression of the other eye, (7) lowering the head below the body, (8) violent physical exercise, (9) paralysis of the vasoconstrictor sympathetic fibers or sympathetic irritation, (10) contraction of the extra-ocular muscles, possibly by causing an increase in intra-ocular pressure, (11) strong accommodation. In addition, one should avoid including subjects with hypertension and circulatory decompensation, or a relative hypertension in the retinal arteries and also those with increased spinal fluid pressure and focal infections, especially of the oropharynx.

Factors tending to decrease the size of the blind spot are: (1) relative arterial hypotension, (2) inspiration of oxygen, and (3) medicines such as sulfonamides and benzedrene sulfate. It is noteworthy that age of the patient has not been included in this listing. It is well known that vitamin A deficiency may produce impaired dark adaptation. Recently, it has been shown that even minor illnesses of short duration tend to have an unfavorable effect on dark adaptation and that deficiency of riboflavin may do the same. This would constitute a source of error when using convalescent patients as subjects.

The following should complete the list of important factors which influence blind spot size: (1) anatomical variations, which Salzman estimates to vary up to 3 or 3 1/2 mm. from the average optic disc size of 1.35 mm., (2) pupillary size, (3) curvature of the cornea, (4) refractive errors, (5) diminished retinal sensitivity (may be localized and, therefore, not discovered in routine visual examination), (6) colobomas and myelinated nerve fibers, (7) physiologic changes in the intra-ocular pressure, e.g. the blind spot is largest in the forenoon when the intra-ocular pressure is greatest.

The normal, continual movement of the fixation point, about .5' in all directions, has a minimal effect on the boundaries, otherwise, all blind spots would have indefinite edges. Thus, the blind spot is in a state of perpetual change in response to nutritive, nervous and mechanical stimuli, but probably even more significant is the cooperation and attention of the subject, his bodily and mental discomfort or fatigue, the reaction time of both examiner and subject; in short, the psychology and intelligence of the patient is of such import that M. Amsler has described perimetry as a psycho-sensorial examination which registers the uncontrollable responses of the subject and is primarily a test of attention. In this regard, two distinct types of individuals have been described; the torpid, with a strong concentration on the point of fixation and delayed recognition of the test object, and a type with accentuated division or actual alternation of concentration in whom the test object is seen early. So far, the variations due to various methods of examination have not been considered. These will be mentioned briefly, subsequently, when describing the conditions of this investigation.

The knowledge of perimetry can be dated to 1593, when Porta determined the visual field (inaccurately) by using a board with a fixation point and stones as test objects. However, the birth of clinical perimetry as a diagnostic procedure was the work of Albrecht von Graefe (1856). In 1862, Forster and Aubert paved the way to rapid, accurate perimetry by the invention of the perimeter, and this has remained the pattern of the many improved models that have since appeared.

One of the most recent and best perimeters, perfected over a period of nine years is the H. Goldmann perimeter (1945). He cannot be too strongly commended for "making more accurate one of the least accurate instruments in this most accurate branch of medicine."

As this instrument was used in this study, its salient features should be described. It is a ball perimeter of 30 cm. radius. The movement, size, color and brightness of the test light is controlled from behind the perimeter shell. Each position of the lever arm for moving the object light indicates a corresponding position of the test object light within the shell. A precise record of the test object position can be made directly onto special paper blanks from the position of the lever arm. The test object light is transmitted from the same light source as that which illuminates the interior of the shell, consequently the relative intensities remain constant with variations in current strength, aging of light bulb, etc. Another singular refinement of this instrument is a telescopic attachment so centered that the objective lens is immediately behind the fixation point. This enables a constant control of the position of the subject's eye and his concentration on the point of fixation. The object light is an ellipse of ratio .7 to 1 with sizes of .25, 1, 4, 16, and 64 sq. mm., and intensities of .31, .31² or 0.096, and .31³ or .03 relative to the original base intensity of approximately 1395 asb, i.e., 31 times the base intensity of the perimeter shell illumination of 40 to 50 asb. These settings were purposely selected to conform with the law, discovered by Dr. Goldmann, that a fourfold increase in object size is compensated, i.e., the visual field remains the same, within certain limits, if the intensity is decreased by .31. The light intensity of the test object can be further reduced by the use of filters, placed before the projector. The shell illumination must then be reduced correspondingly so that the relation of the two remains the same as before. In the following experiment, a filter allowing 10% transmission was also used. As the detection of the test light depends on its absolute intensity as well as the contrast to the background illumination, one would naturally expect enlargement of the blind spot when using the filter. At least twenty eyes from each ten year age group from 10 to 70 years were examined. The subjects were selected at random, all were ambulatory, although many were convalescent, general hospital patients. No distinction was made as to sex, since Berens has shown that no difference exists between the size of the male and female blind spot. The minimum near visual acuity allowed was one correctable to 0.8 (Snellen's charts). The visual field of every eye was checked four times using test object lights of .31 or 139.5 asb and .31² or 13.5 asb. Subjects with obvious diminution or defects of the visual field were discarded. Visual acuity was first determined in a daylight room, then a period of at least ten minutes elapsed for adjusting the perimeter and checking a visual field during which time the sensitivity of the eye was standardized and adaptation to the illumination used could take place; only then was the first blind spot determination made, with the patient wearing his correction. The opposite eye was loosely covered with a blind, thereby avoiding any disturbing flashes of light that might result from a tight bandage over the eye. Only white light was used for the test object for the following reasons: for the sake of comparison as previous experiments and clinical determinations have usually been made using white light, the increased sensitivity of the color blind spot is associated with a great increase in the number of variables and more erratic and confusing results may occur, also a high percentage of people have varying degrees of color blindness, retinal fatigue is said to be maximum for colors, and finally, these objections to color are most marked for the central field area. The test object size was kept constant at one sq. mm. This is a compromise value as a larger test object would give a smaller blind spot, consequently one in which any error would be relatively magnified. A smaller test object would make it impossible for most patients to identify it at the lower light intensities used. The test object was moved with a speed approximating the optimum of 10 degrees in two seconds advised by Dr. Goldmann. It is obvious that if the object is moved too fast an artificially large blind spot would be produced, i.e. the object would continue to travel further during the reaction period of subject and operator, but the strong tendency to anticipate the object by peeking to the side mitigates against going too slowly as well. At least eight points were determined to determine the boundaries of the blind spot and at least one point was doublechecked. Duration of the binocular perimetric examination was 30 to 60 minutes.

The planimeter has been found to be the quickest and simplest means of measuring the size of the blind spot after tracing, and Wentworth states it gives the "most accurate and truly representative index for comparison from person to person." The Amsler Planimeter No. 6 was used with a setting of .05 sq. cm. (1:1), i. e. the reading obtained after tracing around the periphery of the area to be determined and subtracting the reading at the outset could then be multiplied by .05 to obtain the actual area in sq. cm. As this study was initially concerned with a comparison rather than with absolute values, the "uncorrected" results were not multiplied by .05 and consequently, the figures given under this heading are twenty times the absolute or actual values. The blind spot areas were determined with test object lights of approximately 1395, 135, and 42 asb without the filter, and 139.5 and 13.5 asb with the filter. In the subsequent designations, as on the perimeter itself, these are referred to as 4, 2, and 1 respectively, with or without the filter. A number 1, with filter, was not used as most of the patients were unable to see this weak light at all or at best only when looking directly at it.

The test object was moved centrifugally out of the blind spot. Although Gradle, after confirming that the blind spot so obtained was larger than when the test object was moved from outside the blind spot into the insensitive area, has concluded that this was of "little practical consequence," provided a standard procedure was adhered to, most observers such as Incze, Wentworth, and Sisson have found that centrifugal is much more exact than centripetal determination, or even an average of the two, and that the larger blind spot more nearly approximates the true one. This is because fixation is more easily maintained until the test object becomes visible, while if the object is in view the eye tends to follow it, thereby reducing the apparent size of the blind spot. The following small series demonstrates this.

UNCORRECTED DIFFERENCES IN THE SIZE OF THE BLIND SPOT DEPENDING ON
WHETHER THE OBJECT IS MOVED OUT OF OR INTO THE INSENSITIVE AREA.

<u>Without Filter</u>				<u>With Filter</u>			
Object light intensity							
<u>4</u>	<u>4</u>	<u>2</u>	<u>2</u>	<u>4</u>	<u>4</u>	<u>2</u>	<u>2</u>
<u>Out</u>	<u>In</u>	<u>Out</u>	<u>In</u>	<u>Out</u>	<u>In</u>	<u>Out</u>	<u>In</u>
116.0	60.0	160.0	130.0	110.0	92.5	156.6	110.0
120.0	60.0	142.2	100.0	137.5	66.2	163.3	82.8
102.5	33.3	162.5	83.3	103.3	76.6	136.6	96.6
105.0	70.0	133.3	100.0	100.0	60.0	160.0	89.3
126.6	70.0	176.6	67.5	120.0	65.0	180.0	93.3
113.3	71.4	183.3	112.2	116.6	77.5	156.6	81.6
Mean							
113.9	60.8	159.65	98.8	114.6	73.0	158.85	92.3
Difference	53.1		60.85		41.6		66.55
% Difference	53.4%		61.9%		63.7%		58.1%

UNCORRECTED BLIND SPOT MEASUREMENTS, GROUPED ACCORDING TO AGE OF SUBJECT

Age														
10 to 20					20 to 30					30 to 40				
Without Filter			With Filter		Without Filter			With Filter		Without Filter			With Filter	
Object Light Intensity														
4	2	1	4	2	4	2	1	4	2	4	2	1	4	2
153.	160.	383.	160.	216.	130.	166.	236.	120.	200.	154.	200.		190.	
106.	102.	383.	176.		125.	163.	296.	116.	156.	180.	225.		203.	
176.	363.		246.	376.	130.	220.	466.	156.	357.	120.	310.	643.	140.	330.
190.	330.		150.	343.	130.	265.		193.	356.	113.	137.	573.	116.	197.
156.	363.		180.	400.	206.	300.	672.	292.	473.	100.	140.	320.	113.	160.
180.	426.		186.	466.	203.	203.	406.	190.	400.	100.	156.		125.	156.
160.	180.	273.	173.	256.	120.	137.		162.	313.	150.	220.		140.	256.
190.	230.		176.	246.	96.	156.		152.	286.	150.	200.		166.	263.
106.	150.		146.	210.	110.	213.		195.		140.	240.		130.	222.
96.	156.		143.	196.	153.	242.		155.		116.	180.		100.	176.
126.	176.	510.	150.	220.	120.	160.	542.	110.	156.	150.	326.	400.	152.	426.
166.	186.	376.	180.	183.	120.	142.		137.	163.	146.	246.		140.	306.
116.	126.	295.	146.	153.	111.	183.	840.	103.	186.	110.	187.	383.	120.	180.
106.	170.	460.	143.	216.	76.	135.	423.	106.	190.	116.	163.		100.	173.
116.	133.	262.	106.	190.	126.	176.	296.	120.	180.	123.	180.	360.	132.	220.
113.	213.	493.	146.	280.	113.	183.	376.	116.	156.	105.	156.	502.	120.	180.
85.	153.	423.	132.	163.	113.	170.	323.	106.	166.	120.	220.	350.	112.	230.
100.	156.	560.	123.	176.	133.	180.	293.	113.	164.	106.	200.	403.	130.	266.
80.	100.	248.	100.	100.	102.	162.	383.	103.	136.	124.	250.		127.	475.
80.	106.	366.	73.	133.	105.	133.	307.	100.	160.	113.	296.		110.	300.
Arithmetic Mean														
130.5	197.95	387.4	151.75	237.0	126.1	184.45	418.5	142.25	233.2	126.8	212.1	437.1	133.3	250.9
Standard Deviation														
46.	107.5	156.8	51.	108.	42.	53.	203.	57.5	117.	36.5	72.5	190.	41.	108.5

UNCORRECTED BLIND SPOT MEASUREMENTS, GROUPED ACCORDING TO AGE OF SUBJECT
(continued)

Age 40 to 50			50 to 60						60 to 70								
Without Filter			With Filter			Without Filter			With Filter			Without Filter			With Filter		
Object Light Intensity																	
4	2	1	4	2	4	2	1	4	2	4	2	1	4	2			
156.	163.	473.	193.	257.	183.	296.	783.	200.		150.	366.		226.				
143.	192.	270.	153.	186.	133.			186.		150.	263.		160.	260.			
130.	203.		133.	230.	80.	190.	90.			232.	326.		206.	407.			
95.	242.		113.	256.	156.	198.	470.	193.	263.	150.	253.		166.	470.			
203.	286.		224.	306.	180.	230.	453.	280.	296.	130.	136.	330.	156.	176.			
197.	226.		188.	380.	113.	163.	300.	130.	240.	102.	135.	463.	152.	175.			
93.	210.		123.	346.	181.	186.		150.	191.	120.	187.		116.	246.			
123.	306.	796.	143.	326.	140.	163.		176.	210.	83.	245.		102.	237.			
125.	218.	466.	116.	196.	130.	243.		220.	277.	153.			136.				
136.	163.	483.	160.	226.	213.	263.	443.	176.	296.	138.			140.				
133.	190.	343.	170.	226.	183.	190.	413.	185.	261.	190.	326.		260.				
120.	146.		163.	213.	130.	200.		110.	263.	112.	163.		163.	210.			
136.	213.		110.	240.	105.	210.		103.	486.	206.	250.		130.	270.			
130.	210.		120.	270.	126.	140.	320.	116.	156.	103.	145.		123.	170.			
118.	170.		115.	213.	100.	150.	310.	90.	146.	110.	160.		123.	203.			
136.	233.		120.	260.	113.	193.		150.	300.	103.	167.		136.	225.			
130.	197.		116.	276.	116.	160.		143.	306.	100.	276.		117.	486.			
123.	192.		122.	203.	195.	303.		170.	233.	100.	205.		117.	203.			
130.	200.	583.	120.	216.	125.	254.		153.	253.	230.	300.		142.	280.			
133.	176.		116.	200.	175.	235.		147.	241.	100.	173.		100.	180.			
120.	180.	250.	187.	266.	115.	180.		133.	236.	103.	220.		153.	220.			
120.	223.	310.	166.	280.													
Arithmetic Mean																	
133.2	206.3	441.6	144.1	253.3	142.5	207.3	398.0	160.5	258.5	136.4	226.1	396.5	148.8	259.9			
Standard Deviation																	
39.	59.	233.5	45.1	75.	48.	45.5	233.	58.	96.5	54.	88.5	407.	52.	119.			

It is obvious in looking over the standard deviation of these results, that although well over 500 blind spot determinations were made, the series is still much too small to reach a statistically significant conclusion if it is recalled that to be significant, the difference between two groups or means should exceed two times the standard deviation, and that when the sample size is increased 100 times, the precision is increased only ten times while the standard deviation is decreased by only ten per cent. However, it will be noted in the following compilation of the means that the general tendency toward enlargement with age is strongly suggested, although by no means clearly demonstrated.

UNCORRECTED TABULATION OF THE MEANS OF THE BLIND SPOT MEASUREMENTS

Age	Object Light Intensity				
	4	2	1	4	2
10 to 20 years	130.5	198.0	387.4	151.8	237.0
20 to 30 years	126.1	184.5	418.5	142.3	233.2
30 to 40 years	126.8	212.1	437.1	133.3	250.9
40 to 50 years	133.2	206.3	441.6	144.1	253.3
50 to 60 years	142.5	207.3	398.0	160.5	258.5
60 to 70 years	136.4	226.1	396.5	148.8	259.9

There are several reasons why one would expect enlargement of the blind spot with age, such as: easier fatigue, yellowing of the lens and diminished transparency of the refractive media, degeneration and failing power of the retinal receptors which can seldom be discovered even on ophthalmologic examination, general decay in the processes of accommodation, adaptation and adjustment, decreased pupillary diameter which would create the greatest influence under poor illumination. In fact, deterioration of dark adaptation, which amounts to .1 log unit for a ten year age increase between 20 to 30 and .15 log unit between 50 to 60, has been shown by Nitsche and Gunther to correspond to the decreasing pupillary size with age. Thus the area of the pupil decreases progressively from 50.2 sq. mm. in the dark-adapted eye of the 20 year old to 8.05 sq. mm. at age 70, while the proportion of incident light reaching the retina falls from 178 at 20 to an arbitrary base figure of 100 at 40 and 28 at 70. These rather startling facts would lead one to believe that it would be necessary to increase the amount of external illumination in direct proportion to produce the same effect on the retina. This is true "only of conditions approaching complete dark adaptation because it has been found that the luminous efficiency of the periphery of the pupil is less than that of the central portion." (Stiles-Crawford effect.) Also, as the pupil increases in size, the resolving power is increased but the definition of the image is decreased, so that over a range from about 2 to 5 mm. (pupillary diameter) the greater resolving power is quite counter-balanced by a decrease in the sharpness of the retinal image. Other factors to be considered would be the increasing prevalence of subclinical vitamin deficiency states and cerebral sclerosis as well as poorer powers of concentration in the aged. Poorer concentration may well account for the generally higher values obtained for the 10 to 20 year age group.

CONCLUSION:

In conclusion, it may be stated that there appears to be a slight increase in the size of the blind spot with age, but that due to the great number of variables involved and the wide scatter in the determinations, even under standardized conditions, it would take an enormous number of cases to prove this statistically. Also, it may be stated that the increase in the size of the blind spot with age, if it actually occurs, is not sufficient so that any allowances need be made for it in clinical examinations.

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BLIND SPOT SIZE IN CENTIMETERS

RELATED TO REFRACTIVE ERROR

Without Filter

REFRACTIVE ERROR IN DIOPTERS	4			2			1		
	Ht.	WIDTH	NO. OF EYES	Ht.	WIDTH	NO. OF EYES	Ht.	WIDTH	NO. OF EYES
-4.50	1.070	.830	3	1.427	1.087	3	2.03	1.26	1
-2.00, up to, but not including -1.00	.965	.860	6	1.287	.962	6	2.2	1.4	1
-1.00, up to, but not including 0	1.16	.747	7	1.477	1.021	7	2.237	1.450	3
0, up to, but not including +1.00	1.0600	.8408	87	1.2766	.9758	86	1.9851	1.3405	41
+1.00, up to, but not including +2.00	1.0750	.8062	16	1.3844	1.0444	16	2.1250	1.3960	5
+2.00, up to, but not including +3.00	1.065	.797	4	1.325	.967	4			
+3.00	1.04	.66	1	1.20	.71	1	1.81	1.7	1

With Filter

REFRACTIVE ERROR IN DIOPTERS	4			2			1		
	Ht.	WIDTH	NO. OF EYES	Ht.	WIDTH	NO. OF EYES	Ht.	WIDTH	NO. OF EYES
-4.50	1.020	.807	3	1.593	1.090	3			
-2.00, up to, but not including -1.00	1.143	.787	6	1.588	1.120	6			
-1.00, up to, but not including 0	1.174	.896	7	1.557	1.223	7			
0, up to, but not including +1.00	1.1100	1.7642	86	1.4340	1.0467	82	1.883	1.228	10
+1.00, up to, but not including +2.00	1.1175	.8781	16	1.4664	1.0621	14			
+2.00, up to, but not including +3.00	1.160	.9225	4	1.430	1.09	2			
+3.00	1.16	.81	1	1.27	.98	1			

SUMMARY

(All Measurements in Arc Degrees)

Without Filter

	4				2				1			
	NASAL	TEMP.	Ht.	WIDTH	NASAL	TEMP.	Ht.	WIDTH	NASAL	TEMP.	Ht.	WIDTH
AGE 10-20	12.7500	20.0833	9.0833	7.4917	12.1917	20.4500	10.8700	8.0750	11.2750	22.7167	16.0083	10.7833
AGE 20-30	12.5517	19.3375	8.5083	6.7142	11.8583	19.7667	10.6917	7.7000	11.0750	21.7416	17.3833	10.5917
AGE 30-40	12.9833	18.9875	8.5250	6.6750	12.3875	21.0083	11.2167	8.1958	10.8017	22.7183	16.8641	12.4792
AGE 40-50	12.0667	20.0667	9.1417	6.8217	12.3000	20.9917	10.8667	8.8667	12.0625	25.0833	16.9375	12.3833
AGE 50-60	12.3208	19.5333	9.5000	7.0875	11.7417	20.2583	11.2042	8.1792	10.6333	22.5000	16.8642	11.1975
AGE 60-70	11.3583	18.6417	8.7500	7.0079	10.9167	19.8833	11.7460	8.6417	11.1667	22.9067	16.0000	11.2500
AVERAGE FOR ALL AGES												
	12.4885	19.4415	8.91605	6.9663	11.8993	20.39305	11.0992	8.2764	11.1690	22.9461	16.6762	11.4475

With Filter

	4				2				1			
	NASAL	TEMP.	Ht.	WIDTH	NASAL	TEMP.	Ht.	WIDTH	NASAL	TEMP.	Ht.	WIDTH
AGE 10-20	13.2875	20.5125	9.1458	7.2042	11.9708	21.1458	11.8000	8.8792	10.6383	21.8608	16.6108	10.7217
AGE 20-30	12.4250	18.9167	9.3333	6.7667	11.6083	19.9972	12.1833	8.0167	11.6933	13.5388	15.5333	9.8500
AGE 30-40	13.2208	20.2875	8.6542	6.8292	12.2833	21.5083	12.3417	8.6000	11.1667	22.9167	15.2500	11.7500
AGE 40-50	12.7750	20.0167	9.8000	7.1083	11.8917	21.3500	12.0750	9.1083	9.5833	18.7500	14.1667	9.1667
AGE 50-60	12.0000	19.4542	9.6083	7.1708	11.3425	20.7283	12.2850	9.1100				
AGE 60-70	11.5250	18.8583	9.2333	7.3533	10.5500	20.1083	12.1667	9.4250				
AVERAGE FOR ALL AGES												
	12.5389	19.6743	9.2958	7.0721	11.6078	20.8063	12.14195	8.8565	10.7679	19.2665	15.4902	10.3721

SUMMARY

(All Measurements in Centimeters)

Without Filter

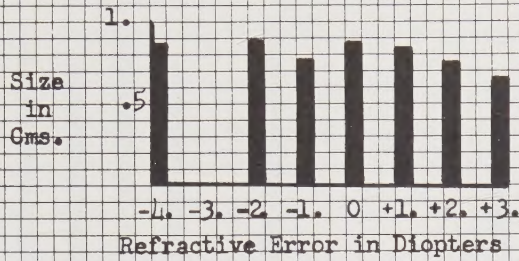
	4				2				1			
	NASAL	TEMP.	Ht.	WIDTH	NASAL	TEMP.	Ht.	WIDTH	NASAL	TEMP.	Ht.	WIDTH
AGE 10-20	1.530	2.410	1.090	.899	1.463	2.454	1.304	.969	1.353	2.726	1.921	1.294
AGE 20-30	1.506	2.3205	1.021	.806	1.423	2.372	1.283	.924	1.329	2.609	2.086	1.271
AGE 30-40	1.558	2.3785	1.023	.801	1.4865	2.521	1.346	.9835	1.296	2.726	2.024	1.4975
AGE 40-50	1.556	2.408	1.097	.819	1.476	2.519	1.304	1.064	1.4475	3.010	2.0325	1.486
AGE 50-60	1.4785	2.344	1.140	.8505	1.409	2.431	1.3445	.9815	1.276	2.70	2.024	1.344
AGE 60-70	1.363	2.237	1.050	.841	1.310	2.386	1.4095	1.037	1.34	2.75	1.92	1.35
AVERAGE FOR ALL AGES												
	1.4986	2.3493	1.0701	.8361	3.5624	2.4470	1.3318	.9931	1.34025	2.7535	2.0012	1.37375

With Filter

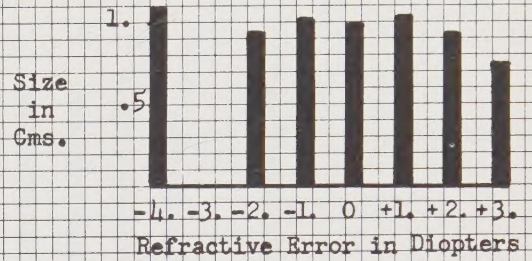
	4				2				1			
	NASAL	TEMP.	Ht.	WIDTH	NASAL	TEMP.	Ht.	WIDTH	NASAL	TEMP.	Ht.	WIDTH
AGE 10-20	1.5945	2.4615	1.0975	.8645	1.4365	2.5375	1.416	1.0655	1.277	2.623	1.993	1.287
AGE 20-30	1.491	2.270	1.120	.812	1.393	2.413	1.462	.962	1.402	2.638	1.864	1.182
AGE 30-40	1.5865	2.4345	1.0385	.8195	1.474	2.581	1.481	1.032	1.34	2.75	1.83	1.41
AGE 40-50	1.533	2.402	1.176	.853	1.427	2.562	1.449	1.093	1.15	2.25	1.7	1.1
AGE 50-60	1.440	2.3345	1.153	.8605	1.361	2.487	1.474	1.093				
AGE 60-70	1.383	2.263	1.108	.882	1.266	2.413	1.460	1.31				
AVERAGE FOR ALL AGES												
	1.5046	2.3609	1.1155	.8466	1.3929	2.4989	1.4570	1.0296	1.2921	2.0652	1.8467	1.2447

BLIND SPOT WIDTH IN CENTIMETERS RELATED TO REFRACTIVE ERROR

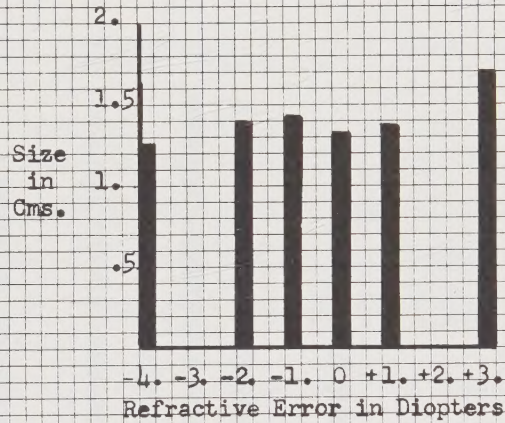
4 without Filter



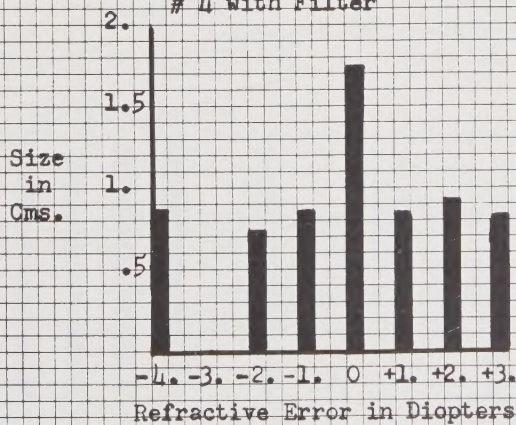
2 without Filter



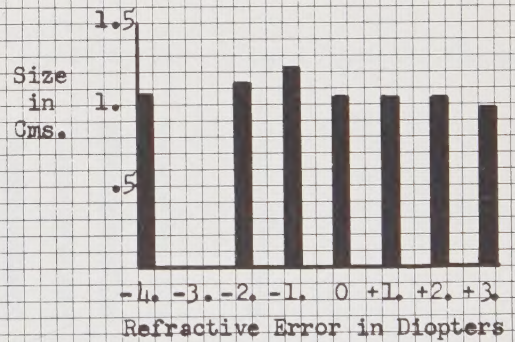
1 without Filter



4 with Filter

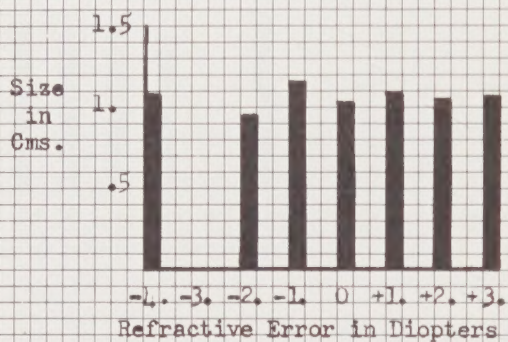


2 with Filter

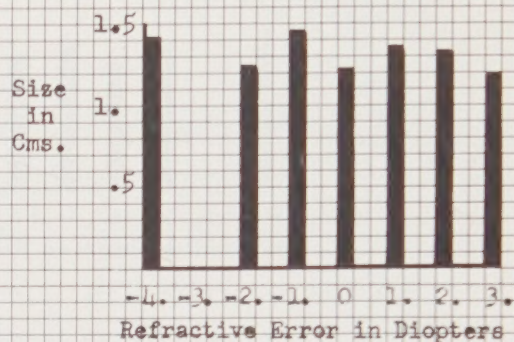


BLIND SPOT HEIGHT IN CENTIMETERS RELATED TO REFRACTIVE ERROR

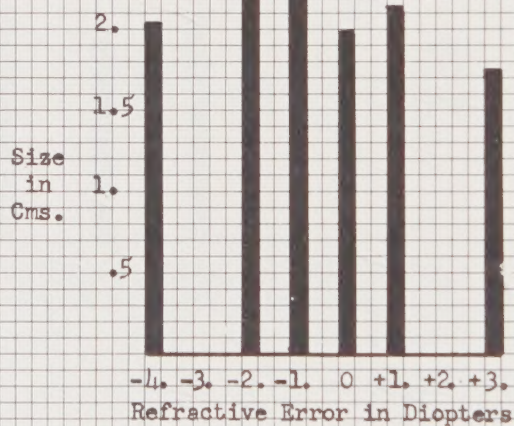
4 without Filter



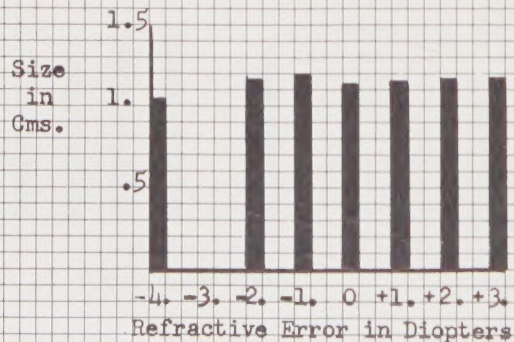
2 without Filter



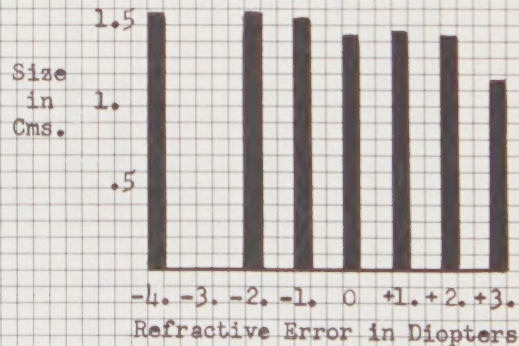
1 without Filter



4 with Filter



2 with Filter



References

1. Amsler, M.: Champ Visuel et Perimetrie: *Confinia Neurologica*, vol. 6-7, p. 112, '44-'47.
2. Berens, C.: Examination of the Blind Spot of Mariotte: *Trans. Amer. Ophth. Soc.*, 21, p. 290, '23.
3. Cobb, P.W.: The Influence of Pupillary Diameter on Visual Acuity: *Am. J. Physiol.*, 36, p. 335, '15.
4. Dubois-Poulsen: Le Ganglion Speno-palatin et L'oeil: *Ann. d'Ocul.*, 174, 217-248, '37.
5. Evans, J.: The Clinical Value of Angioscotometry: *Am. J. Ophthal.*, 14, 772, '31.
6. Goldmann, H.: Ein Selbstregistrierendes Projektionskugelperimeter: *Grundlagen Exakter Perimetrie: Ophthalmologica*, 109, pp. 71, 187, '45.
7. Gradle, H.S.: The Blind Spot: *Ann. Ophthal.*, 24, p. 637, v. 25, p. 740, '16.
8. Hill, B.: *Principles of Medical Statistics*; Pub. by Lancet Ltd.
9. Incze, A.: Über die Richtige Bestimmung des Blinden Fleckes: *Arch. f Augenh.*, 99, 670, '28.
10. Jeans, P., Blanchard, E., Statterthwaite, F.: Dark Adaptation and Vitamin A: *J. Ped.*, 18, 170, Feb. '41.
11. Kimble, M.S.: Photocolorimetric Determination of Vitamin A and Carotene in Human Plasma; *J. Lab. and Clin. Med.*, 24, 1055, July '39.
12. Lauber, H.: *Das Gesichtsfeld*; Krakau, 1944, Springer Verlag, Berlin u. Wien.
13. Luckiesh, M., Moss, F.M.: *The Science of Seeing*, McMillan & Co., London, 1937.
14. Mann, I., Sharpley, F.W.: Normal Visual Field of Dark Adapted Eye; *J. Physiol.*, 106, 301, July '47.
15. Nelson, H.: The Effect of Direct Stimulation of the Blind Spot: *Am. J. Psych.*, 41, p. 345, July '29.
16. Nitsche & Gunther: On the Variation of the Diameter of the Pupil with Age, *Mitteilungen*, 117, Dec. '40.
17. Robertson, G.W., Yudkin, J.: Effect of Age upon Dark Adaptation: *J. Physiol.*, 103, p. 1, '44.
18. Salzman, M.: *The Anatomy and Histology of the Human Eyeball*: Franz Deuticke Verlag, 1912. (Translation by E. Brown.)
19. Sisson, R.: The Blind Spot and Its Pathological Significance: *J. Mich. State Med. Soc.*, 30, p. 142, '31.
20. Sniakin, P.: The Variability of the Blind Spot under some Physiological Conditions: *Arkhiv. Biologicheskikh Nauk.*, 47, p. 61, '37.
21. Traquair: *Clinical Perimetry*.
22. Wentworth, H.: Variations of the Normal Blind Spot: *Am. J. Ophthal.*, 14, 889, '31.
23. Wett, M.: Etude sur les Rapports entre les Dimensions de la Tache Aveugle et la Tension Arterielle Retinienne: *Ophthalmologica*, 109, 137, '45.

